

Efficacy of a bioactive material and nanostructured desensitizing on dentin hypersensitivity treatment

Eficácia de um material bioativo e dessensibilizante nanoestruturado no tratamento da hipersensibilidade dentinária

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Resumo

Introdução: A hipersensibilidade dentinária é uma ocorrência frequente na prática clínica; clinicamente caracterizada por dor aguda, curta e temporária, em resposta ao estímulo mecânico, químico, térmico ou osmótico causada pela exposição dentinária. **Objetivo:** Comparar *in vivo* o efeito de um material bioativo cristalino experimental e um dessensibilizante nanoestruturado na avaliação da dor de pacientes com hipersensibilidade dentinária cervical. **Material e método:** Trinta pacientes foram selecionados para este estudo, que foram randomicamente divididos em dois grupos (n=15) em um desenho experimental de boca dividida. Cada paciente recebeu dois tratamentos: grupo 1 (flúor gel e material bioativo) e grupo 2 (flúor gel e dessensibilizante nanoestruturado). As análises de dor foram realizadas usando uma escala visual analógica, variando de 0-10. A mensuração da dor inicial foi realizada previamente ao tratamento inicial (T₀) e novas análises foram realizadas semanalmente durante 3 semanas (T₁, T₂ e T₃) antes da reaplicação dos materiais. A análise final da dor foi realizada 3 meses após o início do tratamento (T₄). O grau de redução de dor foi mensurado pela fórmula: T₀ - T_{período após tratamento}. Os dados das mensurações de dor foram analisados pela ANOVA para medidas repetidas 2 critérios e teste de Tukey (α=0,05). **Resultado:** Independente do período de avaliação, não houve diferença estatística entre todos os tratamentos na redução da dor (p>0,05). O grau de dor reduziu significativamente em cada período avaliado para todos os tratamentos testados (p<0,05), aproximadamente três graus após 3 meses. **Conclusão:** Os materiais dessensibilizantes testados foram efetivos na redução da hipersensibilidade dentinária.

Descritores: Dessensibilizantes dentinários; sensibilidade da dentina; dor.

Abstract

Introduction: Dentin hypersensitivity is a frequent occurrence in dental practice. It is clinically characterized by acute, short, and temporary pain in response to mechanical, chemical, thermal, or osmotic stimuli resulting from dentin exposure. **Objective:** To compare *in vivo* the effect of an experimental crystalline bioactive material and nanostructured desensitizing on the pain assessment among patients with cervical dentin hypersensitivity. **Material and method:** Thirty patients were selected for this study, who were randomly assigned to two groups (n=15) in a split-mouth design. Each patient received two treatments: group 1 (fluoride gel and bioactive material) and group 2 (fluoride gel and nanostructured desensitizing). Pain analyses were performed using a visual analogue scale, ranging 0-10. Baseline pain measurement was performed prior to initial treatment (T₀) and new measurements were carried out weekly for 3 weeks (T₁, T₂, and T₃) before materials were reapplied. Final pain analysis was performed 3 months after initial treatment (T₄). Degree of pain reduction was calculated using the formula T₀ - T_{period after treatment}. The data of the pain measurements were analyzed using 2-way repeated measure ANOVA and Tukey's test (α=0.05). **Result:** Regardless of evaluation period, there was no statistical difference on pain reduction between the treatments (p>0.05). The degree of pain was reduced significantly in each evaluated period for all tested treatments (p<0.05), by approximately three degrees after 3 months. **Conclusion:** The tested desensitizing materials were effective on dentin hypersensitivity reduction.

Descriptors: Dentin desensitizing agents; dentin sensitivity; pain.

INTRODUCTION

Dentin hypersensitivity (DH) is a very frequent occurrence in daily dental practice showing incidence as high as 74% but, in most populations, it appears to range between 10-30%¹. It is clinically the result of dentin exposure and is characterized by acute, short and temporary pain in response to mechanical, chemical, thermal, or osmotic stimuli and cannot be attributed to any other dental pathology¹⁻⁴. The most widely accepted theory to explain DH is Brännström's hydrodynamic theory⁵ and one of its main causes is non-carious cervical lesions such as abrasion, erosion, and abfraction⁶. In addition, gingival recession also exposes the underlying dentin^{1,4}.

The treatments indicated for dentin hypersensitivity are numerous^{2,7-10} and are based on either the obliteration of the dentinal tubules to prevent movement of intratubular fluid, or neural blockage of pulp mechanoreceptors, or both¹¹. The treatments that act on the pulp nerve mechanoreceptors use potassium salts, tin and strontium which, when present in oral environment, are released in ionic form thus decreasing pain transmission. However, the interruption of treatment leads to a decrease in the concentration of these ions surrounding the mechanoreceptors resulting in the re-establishment of painful stimulus^{6,12-14}. Regarding treatment through dentinal tubule obliteration, several substances such as strontium chloride, fluoride, potassium oxalate, inert ceramic particles like silica, alumina, and arginine, among others^{1,4,7,13,15-17} may be used. The fluoride reacts with calcium forming calcium fluoride (CaF₂) crystals and decreasing dentin permeability. However, the crystals are small and dissolve quickly when exposed to acid solutions¹⁸.

A desensitization and remineralization, using nanostructured calcium phosphate organized in the crystalline form of hydroxyapatite (Nano P), has been recently introduced in the dental market. According to the manufacturer, the effectiveness of this material is based on its ability to provide ions of calcium, phosphate, and fluoride to demineralized tooth surfaces, which can be reorganized in the form of hydroxyapatite, fluorapatite, and calcium fluoride, with acid resistance similar to that of the natural tooth. In addition to this characteristic of remineralization, based on the ability of the hydroxyapatite layer to occlude the dentinal tubules¹⁹, potassium nitrate depolarizes the nerve fibers thereby decreasing the pain^{6,12-14}.

Another promising material for the treatment of dentin hypersensitivity is the bioactive glass-ceramic (biosilicate). This product is a fully crystalline glass-ceramic, produced by modifying the structure and concentration of the initial bioglass components through thermal treatment. That results in the formation of polycrystalline microstructures having crystals with controlled size and volumetric fraction¹⁶. This change results in particles with lower cutting potential and proven biological properties^{20,21}, reducing dentin hypersensitivity²². Previous studies have shown that, after biosilicate application on the dentin, deposition of hydroxycarbonate apatite in open dentinal tubules was observed, forming a uniform layer over this surface^{23,24}.

However, no hypersensitivity treatment was shown to be fully effective for all patients. Therefore, this study aimed to compare the effect of bioactive glass-ceramic and nanostructured desensitizing among patients with non-carious cervical lesions and dentin hypersensitivity, in a split-mouth design having fluoride as the

control treatment. The hypothesis was that the materials evaluated would reduce or eliminate dentin hypersensitivity.

MATERIAL AND METHOD

This study was approved by the Research Ethics Committee (protocol # 243.771) of Paulista University. The procedures followed were in accordance with the ethical standards of the committee on human experimentation and with the Helsinki Declaration of 1975, as revised in 1983. Thirty patients were selected (Figure 1) in a single-center, meeting the following inclusion criteria: aged 18-60 years, presenting at least 2 teeth with DH (maxillary premolars, one in each dental arch), not subjected to periodontal treatment in the last 3 months, presenting periodontal health, non-smoker, presenting non-carious cervical lesions (abrasion, abfraction and/or erosion) or dentin exposed by gingival recession, not presenting occlusion interferences in the selected teeth, and not subjected to orthodontic treatment in the last 6 months. Patients using occlusal splint, mouthwashes, medications (such as analgesics, antidepressants, anxiolytics, and anti-inflammatory drugs), with amelogenesis or imperfect dentinogenesis, cervical restoration, patients who underwent dental bleaching within the last 6 months, pregnant women and nursing mothers, patients with digestive disorders and those in orthodontic treatment, were excluded from the study.

After signing an informed consent, the patients underwent anamnesis to determine oral history, dietary information, oral hygiene routine, and description of events that cause hypersensitivity. In addition, an extra-soft bristle toothbrush and 1,100 ppm fluoridated toothpaste without desensitizing were provided for standardization of patients during the study. They received instructions for brushing (45° at the dental surface, with slight pressure and light movements), prior to the beginning of treatment⁷.

The split-mouth design was selected for this trial and the study was double-blind. Initially, the area to be treated was relatively isolated. A prior mechanical cleaning was performed in the sensitive area using a cotton swab soaked in distilled water²³. Then, a stream of compressed air (~ 10 °C, 40-65 psi) was blown for 2 s, at 1 cm, perpendicular to the tooth surface while adjacent teeth were protected by the operator's gloved fingers and cotton rolls. The patients' hypersensitivity was quantified using a visual analogue scale (VAS)⁷. This VAS ranges from 0 to 10, where 0 means complete absence of pain and 10 the maximum level of pain bearable by the patient.

Each patient received two treatments (fluoride [control] and tested material), one treatment on the maxillary premolar of each dental arch. The patients were randomly divided into two groups (n = 15) according to the treatment being performed. Group 1 (G1): 1.23% acidulated phosphate fluoride gel (DFL Ind. Com. Ltd., Rio de Janeiro, RJ, Brazil) and bioactive glass-ceramic material (Biosilicate[®]; Vitrovita, São Carlos, SP, Brazil). The fluoride gel was applied using a micro-applicator for 1 min on the exposed dentin surface. For bioactive material, a mixture of 0.100 g of powder with 1 mL of distilled water (1:10 ratio) was applied for 5 minutes^{22,24}. Group 2 (G2): fluoride gel and nanostructured desensitizing (Desensibilize Nano P; FGM Dental Materials, Joinville, SC, Brazil). The fluoride was applied as reported for Group 1. The nanostructured desensitizing

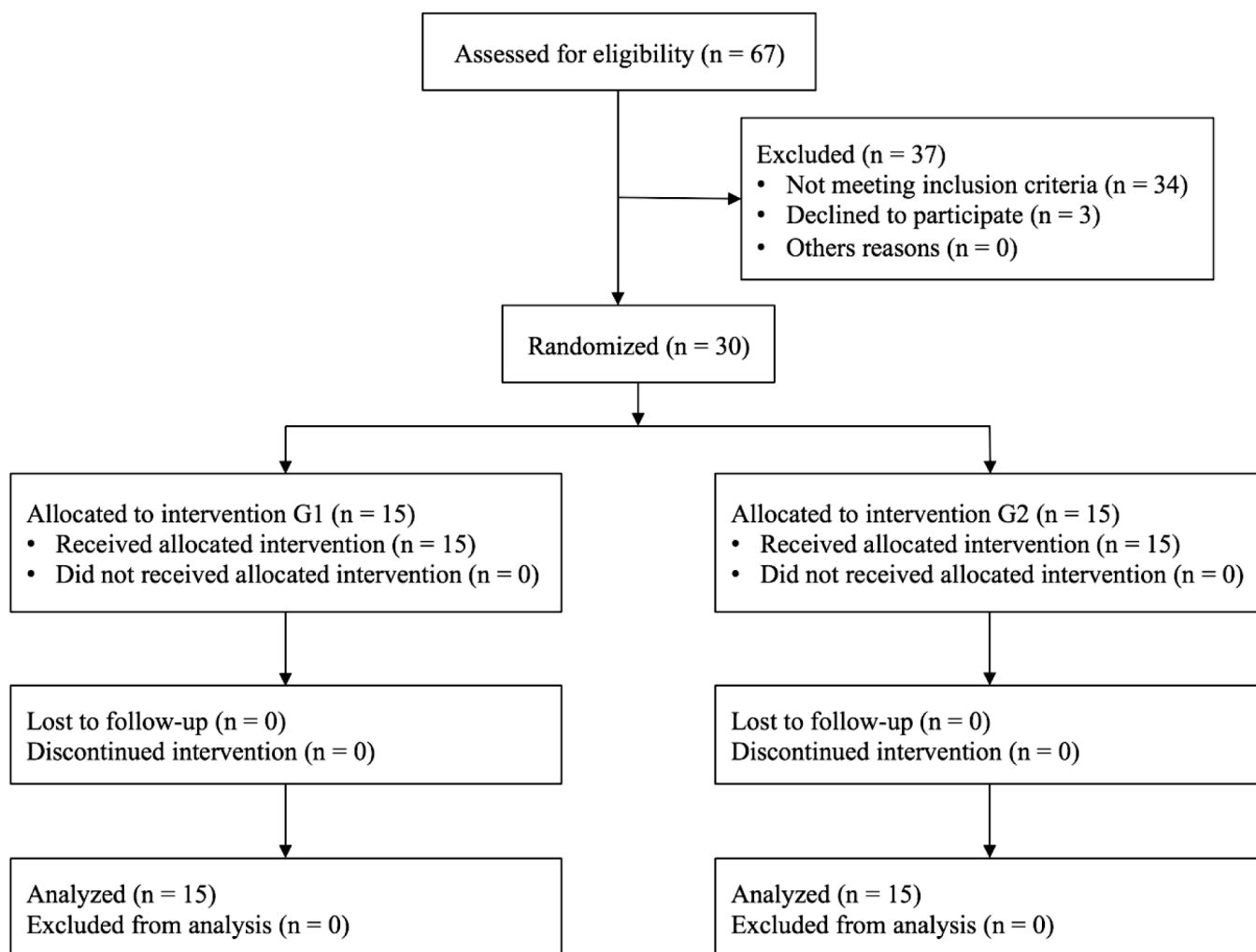


Figure 1. Participant flow diagram. G1 - fluoride and biosilicate. G2 - fluoride and Nano P.

was applied according to the manufacturer’s instructions using a micro-applicator (friction for 10 s with felt disc and left for 5 min).

Baseline pain measurement was performed prior to initial treatment (T₀), then desensitizing materials were applied as previously described. New measurements were carried out weekly for 3 weeks (T₁, T₂, and T₃), immediately before materials were reapplied. Final pain analysis was performed 3 months after initial treatment (T₄). Degree of pain reduction was calculated using the formula: T₀ - T_{period after treatment}. All patients completed all follow-up controls.

The degree of pain data were statistically analyzed using two-way repeated measures ANOVA (analysis of variance) followed by Tukey HSD (honest significant difference) post-hoc tests at a pre-set alpha of 5%. The factors considered were treatment (in 4 levels: fluoride in G1 patients, bioactive material, fluoride in G2 patients, and nanostructured desensitizing) and period of evaluation (in 4 levels: T₀-T₁, T₀-T₂, T₀-T₃, and T₀-T₄).

RESULT

All patients who participated in this study received treatment; the mean of the initial degree of pain was about 5 for both groups. The means and standard deviations of degree of pain reduction are presented in Table 1.

Table 1. Degree of pain reduction means (standard deviation) according treatment and period of treatment

Treatment		Period of treatment*			
Group	Material	T ₀ -T ₁	T ₀ -T ₂	T ₀ -T ₃	T ₀ -T ₄
1	Fluoride	0.9 (0.5)	1.2 (0.6)	2.5 (0.5)	3.1 (0.5)
	Biosilicate	1.4 (0.5)	2.2 (0.5)	3.1 (0.4)	3.8 (0.4)
2	Fluoride	1.3 (0.4)	2.2 (0.5)	2.8 (0.6)	3.2 (0.6)
	Nano P	1.1 (0.4)	2.0 (0.5)	2.5 (0.7)	3.2 (0.7)

*Statistically significant reduction in mean degree of pain in each period (Tukey: p < 0.05 for all). Equivalent between treatments (ANOVA: p > 0.05).

ANOVA showed no significant difference between treatments (p > 0.05). For all treatments, a statistically decrease on degree of pain was observed at the return of the patient for a new application, compared to the baseline (p < 0.05). The mean pain intensity decrease was about three degrees at the end of the three-month period.

DISCUSSION

DH etiology is due to dentin tubule exposure, manifesting as short, acute pain, and caused by thermal, chemical, and osmotic stimuli¹⁻⁴. There are several proposed treatments, showing effectiveness in different degrees and times, but a permanent solution is not complete. There also may be relapses, mainly due to the fact that the substances used in the treatment do not remain for long on the tooth surface². Thus, the treatment for DH has been a challenge for both clinicians and researchers.

In this study, the acidulated phosphate fluoride group was used as the control group. Sodium fluoride can be easily diffused by the enamel and precipitated as fluorapatite and fluor-hydroxyapatite⁷. The CaF₂ crystals, formed when the fluoride comes into contact with the calcium and phosphate ions, obliterate the entries of dentinal tubules, decreasing dentin permeability^{2,7}. However, being unstable, the effect is of short duration; hence, the need for multiple treatment sessions. Another inconvenience of fluoride is the size of the crystals formed, which are smaller and less effective than those formed by other compounds^{22,24}.

The acidulated phosphate fluoride is more reactive than the neutral, so this was chosen for the present investigation. The pain intensity decreased over time, after topical application of fluoride on the exposed dentin. The pain decrease was about three degrees at the end of the three-month period. A previous study⁷ observed a significant decrease in pain only after 3 months of using acidulated phosphate fluoride, justifying the claim that agents containing sodium fluoride do not result in precipitates able to effectively block the dentinal tubules. However, in the present investigation, pain reduction was observed at the second visit of the patients.

Another product tested was a nanostructured (NanoP) desensitizing product, with the capacity to provide calcium, phosphate, and fluoride ions to the demineralized tooth surface, which can be reorganized in the form of hydroxyapatite, fluorapatite, or calcium fluoride. The desensitizing effect is due to remineralization, which is based on the ability of the hydroxyapatite layer to occlude the dentinal tubules¹⁹, in addition to the effect of nerve fiber depolarization by the potassium nitrate present in the material^{16,12-14}. This product also resulted in pain decrease over time.

The experimental bioactive glass-ceramic material (biosilicate) is an innovation in the ceramic glass bioactive area, developed at the Laboratory of Vitreous Materials of São Carlos Federal University. Its chemical composition is P₂O₅-Na₂O-CaO-SiO₂ and is biocompatible^{20,21,23}. The bioactive glass-ceramic, in contact with fluids, starts the chemical reaction. Thus, when this material was applied on the dentin surface, it showed deposition of hydroxycarbonate apatite, occluding the open dentinal tubules. It could be a promising desensitizing agent for the treatment of dentin hypersensitivity^{23,24}. Similar to the results of the present investigation, a previous study also found greater absolute pain reduction after biosilicate application²².

It was observed in the present study that, regardless of the material evaluated, after 3 months of treatment all desensitizing agents were able to decrease dentin hypersensitivity and provide a significant reduction in pain when compared with initial pain (baseline). As in the present investigation, many studies have shown that treatment with desensitizing agents decreases hypersensitivity over time^{1-4,6,7,12,15,19,22}. The acting speed of the materials used for DH treatment is an important factor to be considered. All materials tested showed pain reduction over time. The pain reduction was about three degrees after 3 months, thus the hypothesis tested was accepted.

The clinical evaluation of pain among patients with DH is problematic, as several factors may modify the response of volunteers. One difficulty is the cooperation of volunteers and their commitment to return visits. There are also difficulties with the interpretation of dentin hypersensitivity in the results of clinical studies, since responses of the body itself may lead to a pain reduction. However, it was evident in the present study that the desensitizing agents were effective in reducing the sensitivity within an acceptable period of time, improving the patients' comfort. In addition, the tested biomaterial proved to be very promising, and other *in vivo* and *in vitro* studies should be conducted in order to verify its efficacy.

CONCLUSION

It can be concluded that there were no significant differences between treatments evaluated and, at the end of three months, all tested desensitizing agents reduced dentin hypersensitivity.

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CONFLICTS OF INTERESTS

The authors declare no conflicts of interest.

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